RESOURCES

Some findings and conjectures from
recent research into resource development and use

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Every discovery that has extended the circle of the known has enlarged the perimeter of the unknown. —FOREST RAY MOULTON

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The Endless Adventure

GEORGE BEADLE'S opening words at the first of our 1959 Forum series on Science, Resources, and Society provide, it seems to me, a fitting introduction to these seasonal summaries of research. "It is an unending sources of wonderment," he said, "that out of minute spheres of jelly-like protoplasm little larger than the point of a dull pin there should develop living beings like you and me." He spoke with awe of "this tiny sphere, the fertilized egg of man," wherein is locked "the secret of man's origin from subhuman ancestors and the nature of his destiny in an evolutionary future now unknown."

Long before there were magnetic resonant spectroscopes, or microscopes, or powerful telescopes; three centuries before man could see in the nucleus of the atom an order and system more complicated than the solar system, a mathematician of the Renaissance, Blaise Pascal, discerned a like relationship and continuum, with no end to it: "All the sciences are infinite in the extent of their researches . . . and do not permit of finality."

To explore the globe and no small part of the universe; to gradually discover that our world is not a world of caprice but a consistent world where verification is always possible, provided identical conditions obtain; to increase in control of our environment and thus obtain an ever increasingly high standard of living; and through communication to transmit our observations and interpretations to generations yet unborn—that is humanity's greatest adventure.

R. G. GUSTAVSON, *President*
Resources for the Future

SWEET WATER BY SUNPOWER

THE KING of Libya's favorite palace is in Tobruk, a town of around 5,000 people at the edge of the Libyan Desert on the Mediterranean shore. Rainfall there is less than five inches annually; there are no surface streams or lakes. The well water is heavily laden with salt, and the king's private supply of potable water is brought in by truck from another of his palaces some 200 miles away. For sanitary purposes the people of Tobruk use piped water from wells with a saline content of about 3,000 ppm. They drink brackish water hauled in by truck from Bardia, about 75 miles distant. The water they drink analyzes 1,100 ppm—more than twice as salty as is considered tolerable in this country, and it costs $14 a thousand gallons, as compared with an average cost under 25 cents a thousand gallons over most of the United States.

The king has considered supplying Tobruk's water needs by a 200-mile pipeline from near the source of his own supply. But that would cost over $5 million, an expenditure beyond economic justification for only 5,000 beneficiaries. So last December, in response to a request from the ICA, George O. G. Löf went to Libya to explore the possibilities of solar distillation or other alternatives.

The British foreign aid program in Libya has also been concerned with this problem, and within the last few months it has been responsible for the installation of an electrodialysis system for desalin-

izing 5,000 gallons of the salty well water per day. A hospital now being built under United States auspices will install a similar plant. Partly because of high-priced power—around 8½ cents a kilowatt-hour—the operating costs by this process will come to around $2 per 1,000 gallons of demineralized water.

Construction costs for solar distillation are higher, but operating costs are lower. The main requirements are a lot of spare ground and a lot of sun. Libya has both. Labor for digging basin-type pools for solar distillation costs less than a dollar a day, and sunpower is free. The costs of thus obtaining sweet water will be compared with those of electrodialysis at Tobruk, and with corresponding costs of solar-stills lately projected at a pilot plant by the Battelle Institute (for the Department of the Interior) near Daytona Beach, Florida.

Here, three such stills are nearing completion. Two are 2,500 square feet in area and the third is a "farm-size" unit, 500 square feet. The larger stills are expected to provide about 250 gallons of distilled water on sunny days, and the smaller one about 50. The sun warms the salty waters in black-bottomed ponds or basins covered with glass or a transparent film-plastic. The evaporated moisture runs down into troughs which carry it to storage.

Electric power at Tobruk is currently produced by five 250 h.p. diesels. The fuel bill for this runs high and is no slight factor in the heavy net import requirements of Libya and its million people. A solar still can desalt sea water quite as readily as brackish well water, with no increase in minimum operating costs. Given these conditions, the prospects for producing potable water economically by sunpower in parched lands such as Libya appear nearly within reach.

An engineer and consultant with RFF, George Löf made the initial design for the Florida solar-stills. He has collaborated on a book-length study of Technology in Water Development, just published by The Johns Hopkins Press.

THE RAINDROP AND THE BOMB

THE RFF FORUM for 1959 took the form of six public lectures and discussion programs this winter. The fields of research, successively considered, were these: in January, Genetics, then Weather Modification; in February, Mineral Exploration and Chemical Technology; and finally Nuclear Energy and Outer Space, in March. Even these few briefed passages from the first two programs may serve in some part to indicate how spheres of inquiry once considered far removed are drawn into merging circles of common concern, under impact of related findings in this Atomic Age.

TO WHAT END? . . .
A third fewer farm people produced over 55 per cent more farm products in 1958 than in 1938, while the U. S. population increased a little more than a third. But how much further can the process go? In the United States? In the World?

—Oris V. Wells

GENETIC DIFFERENTIALS . . .
World population now increases at the rate of about 48 million a year. Probably 30 million are births where the income per capita is less than one tenth that of the United States and where the percentage of illiteracy is more than half. These 30 million, born into areas where the people have seen their misery steadily increasing year by year, will, as their numbers soar, become the most powerful political force in the world.

Ten years hence there will be at least one and a third billion people whose standard of living, already low, will have gone down as the standard of living in the United States, Western Europe, the Soviet Union, Canada, and Australia will have gone up.

The dropping of the atom bomb is not probable but the terrific tension resulting from this growing discrepancy is certain.

—Henry A. Wallace

"MOST FRIGHTENING . . ." *In the discussion period, Mr. Beadle, who had flown here from England to present the opening paper of the Forum, was asked if he could clarify apparent divergencies of scientific opinion on the effects upon human populations of fall-out from nuclear explosions. This was his reply:*

If the products of nuclear devices —weapons, reactors, and others— are not contained, they pollute man's environment and will surely increase his mutation rate. New mutations arising in this way may be transmitted to future generations if they occur in the germ plasm prior to reproduction. With present methods and current levels of testing, it is calculated that the mutation rate in man may be increased by as much as one per cent . . .

"This is a small increase, but it means that for every 100 mutations without testing something like 101 may occur with it . . . In terms of absolute numbers of new transmitted mutations per generation

on a world basis, it may affect as many as 200,000 individuals . . .

"There is a considerable uncertainty in these calculations, and geneticists cannot now say how these mutations will be distributed with respect to the various categories of final effects. Some will be eliminated in ways that will cause little damage in terms of human suffering or social burden. Others will surely be more serious.

"The relative importance attached to the genetic hazards resulting from nuclear weapons testing tends to vary among individuals — including geneticists and other scientists—according to their attitudes toward military, political, moral and other aspects of the nuclear weapons problem. Those who believe that ultimate survival is likely to depend on great capability in nuclear weapons tend to minimize the genetic cost in testing them. On the other hand, those who hold that abolishment of nuclear weapons is both desirable and attainable as a means of averting global catastrophe are inclined to use genetic hazards of testing as one of their important arguments. That summarizes the genetic side of the problem, it seems to me.

"Speaking now as a citizen, I look upon the continued buildup of nuclear weapons as a most frightening business, partly because testing them creates hazards, but mainly because having them by more and more nations constitutes a risk of all-out war that seems intolerable to me. I sincerely hope, therefore, that an effective way to reverse present trends will be found—and soon."

OF WEATHER AND CLIMATE . . .
The basic paper on Weather Modification, at the second session of the Forum, was presented by Horace R. Byers. "Rainmaking quackery or pagan ritual," he remarked in opening, dates from the Stone Age, and the beginning of scientific weather modification from 1946 only. At present: "In cloud physics we have a case of where people tried to run before they had learned to walk. Now we need desperately to go through some of the beginning steps." Even so—

"As we find ourselves releasing thermonuclear energy in amounts of the same order of magnitude as the energy released by small tropical storms, we cannot help but think that weather modification, not just cloud modification, is coming within our grasp."

Beyond that, climate modification is a demonstrable possibility, made manifest in 1883 by an Act of God. Then—

"THE VOLCANO KRAKATAO
in the Sunda Strait between Java and Sumatra spewed forth the greatest eruption of modern times. The volcanic dust was noticeable in the atmosphere for more than three years. It modified the weather of most of the Earth to the extent of lowering the average annual temperature observed at stations then in existence by about 1° F. Similar effects have been observed from other great eruptions . . .

THE RUPTURED TROPOSPHERE . . .
"The first thermonuclear explosion in the Marshall Islands in 1954," said Senator Clinton P. Anderson in his supporting paper, "not only vaporized a small coral island, it ruptured the troposphere, spewing into the stratosphere countless tons of radioactive debris. We have proof that this debris is being precipitated in both hemispheres . . .

"Just as it may have seemed that something was at last to be done about the weather, along came an invisible radioactive rain to invade our bones, affect our genes and thus tamper with our evolution . . .

"Many military experts may regard the ICBM as the ultimate weapon, but weather warfare may well be . . . What if it lay in the power of another country to deny us at will our drinking water or our wheat crop, to alternately freeze us or burn us up; to flood our cities and scorch our farms?"

PROGRAM NOTE: The three who lectured on Genetics are especially notable products of Lahd Grant Universities. George Beadle, now on leave from the California Institute of Technology as a visiting professor at Oxford, took his first degrees at the University of Nebraska; Henry A. Wallace at Iowa State; Oris Wells, of the Agricultural Marketing Service, at New Mexico A and M.

Horace R. Byers is head of the Department of Meteorology at the University of Chicago. Clinton Anderson, formerly Secretary of Agriculture and since Senator from New Mexico, serves as Alternate Chairman of the Joint Committee on Atomic Energy.

Their entire papers, and fourteen others presented later in the Forum, are being made into a book to be published this year by The Johns Hopkins Press.

MALTHUS REVALUED

GOOD THEORY, like good art, simplifies, abstracts, and highlights. It is therefore, in a sense, inappropriate to ask whether Malthus believed his conditions to be complete and detailed descriptions of reality. Of course, he did not. A really good theorist is a hair-splitter only when necessary, or when engaged with a critic. The proper question is whether Malthus believed his theory and conditions to be essentially accurate. And to this, the answer is certainly that he did . . .

In Malthus' time, . . . a considerable part of "final" or virtually final output was agricultural goods . . . Thus, if a man stood on a square mile of land, or a nation on 3,000,000, the natural resources relevant for economic activity could be easily indentified and measured. They were acres of cropland and pasture, board feet of standing timber, etc.

What has happened since those times to the meaning of final goods, the methods by which they are produced, and the definition of natural resources is so profound

that we find the novelty difficult and seek simplification in possibly archaic analogies . . . More than 90 per cent of the increase in real gross national product in the United States since 1870 has been of non-agricultural origin . . . Finally, the natural resource building blocks have changed radically —they are atoms and molecules . . .

In significant degree, even the ultimate limits are different from Malthus'. His natural resources were conceived for a two-dimensional world nourished by acreage. Ours is a three-dimensional one, sustained by subsurface resources. His society could reach natural resources to only insignificant distances above and below his acres. We have multiplied our "reach" by many thousands.—*Harold J. Barnett, of RFF, at the Universities-National Bureau Conference in December, 1958.*

The Energy Base

THE TERM "resource base," as used by Bruce Netschert, of RFF, derives from a concept he has developed in seeking to measure the availability of oil and gas in the United States through 1975.

Hitherto, estimates of petroleum supplies have been based on what is commonly called "proved reserves." That is industry's shorthand for "proved recoverable reserves"—which is to say supplies that are definitely known and that feasibly can be extracted at current costs with current technological processes. At the end of 1958 proved reserves of oil in the United States were 30 billion barrels, against an annual production of 2.4 billion barrels. This has given rise to dire predictions as to future domestic scarcities and consequent increasing demands upon imports.

The Netschert concept makes it possible to place a quantitative estimate on the whole of a particular resource provided by the environment of a given area. Of oil, for instance, it is generally believed that only one-third of the oil in the earth's crust is recoverable by current methods in this country. Accordingly, industry's estimate of total future supply (which ranges between 86 and 240 billion barrels, depending upon the estimator's methods and cast of mind) may be multiplied by 3 to give an assumed resource base.

Netschert comes up with 500 billion barrels as his resource base for oil in the United States, of which 30 billion are "proved reserves" and 208 billion are known but as yet uneconomic to produce. Between the limits of "reserves" (30 billion) and the "resource base" (500 billion) there is a middle ground for which he uses the term "resources." The resources consist of that portion of the resource base (including reserves) which seems likely to become available given certain technological and economic conditions. For example, one may wish to estimate the oil resources that would obtain at twice present costs. Such a quantity would include a portion of the 208 billion barrels noted above (i.e., whatever it is estimated could be recovered at such costs) plus the quantity of as yet undiscovered oil which it is estimated would be discovered and produced under such cost conditions.

Applying this formula to the domestic availability of crude oil in the United States in 1975, Netschert reaches the reassuring conclusion that, with no appreciable increase in constant dollar costs, around 6 billion barrels of oil could be available. Of this, 4 billion barrels could be produced through primary recovery (a 57 per cent increase over the 1958 level of production); the remaining 2 billion could be produced through secondary recovery.

KEY FACTORS IN REGIONAL GROWTH

I BELIEVE THAT an effective economic development program can be evolved only if its architects can come to look at the economic structure of a state or region in economically meaningful terms. When one refers to "agriculture," "manufacturing," and "services," he is using a convenient shorthand description of a highly complex and diverse set of economic activities, which in some cases hides more than it reveals . . .

It is surprising how often the long-term decline in the number of persons needed to produce farm products gives rise to the illogical conclusion that agriculture is an undesirable economic activity for a state or region, and that manufacturing industry alone should be considered. Some agricultural activities make out very well indeed in some parts of the country. It is much more meaningful to characterize economic activities as high-, medium- and low-income-producing, or again in terms of high-, medium- and low-potentiality for growth . . . Most important of all is the classification of economic activities according to advantages or disadvantages. Thus, the question is not only "which industries are good for us," but "which industries can do well within our state?" —*Harvey S. Perloff, of RFF, at the Governor's Conference on Economic and Social Trends in Iowa.*

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